Analysis of the Design of an HVAC System in a Public Building

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Abstract: Based on an example of the design of air conditioning system for a public building, this paper analyzes the characteristics of similar buildings, and introduces the air conditioning system, ventilating system, and the fire control system. The optimized combination of these three systems is carried out in this building to meet the demand on comfort, energy conservation, and fire control and protection, which can provide a reference for the design of similar buildings.

Key words: underground building; air conditioning system; fire control and protection; energy conservation

1. INTRODUCTION

A public building lies in a city north of China, which is reconstructed by an underground building among many buildings. This public building is 30 meters width from north to south, 55 meters width from east to west, 2.5 meters high, 1560 m2 in area, fire resistant rating, with four exists. It is planed the reconstructed as a public building with the function of amusement, recreation and performance, so the air conditioning system is necessary. In this architecture, the building is consist of forty seven rooms with area of 10 m2, 15 m2 and 20 m2，one water bar with area of 40 m2 ,and the area of structure of the largest amusement hall is 199 m2. The building, as a public building, is strict in functional design, including air conditioning, ventilating system, fire control system, so the safety audit is strict, and the key problem is the examination and approval of the means of escape on fire control and protection. Based on the rules of GB50189-2005 DESIGN CODE OF ENERGY CONSERVATION IN PUBLIC BUILDINGS, considering the large ventilating volume, this design consist of the three aspect of air conditioning system, ventilating system, fire control system.

2. DESIGN PARAMETERS

The noise grade should meet the demand of operating requirements in public buildings. The temperature and humidity indoor should meet the demand of comfort standard of moderate physical laborers, considering the characteristic of some of the KTV rooms. This underground building did not install heating system, so the multi on-line air conditioning system works for the heating and cooling all the year. As the long work time of amusement center, the concept design of air conditioning system is based on the whole day time, but in the whole day, the load of the system is vary from high to low irregularly in every KTV room. With the consideration of creating a healthy and comfort place, the design should pay more attention to the supply of enough fresh air. The density of human beings in one KTV room is 0.6 person/ m2, the people gathering coefficient is 0.98. The fresh air volume of every person in one KTV room is 25-30 m2， The parameters indoor are listed in table 1 [1].

This underground building should locate fire control system based on related rules. This building is divided two fireproof zones, eight smoke proof zones. The largest smoke proof zone is 199m2. One induced-draft fan burdens two smoke proof zones, its exhaust smoke level is higher than 120m3/（h·m3）, and the fresh air should be more than half the exhaust smoke volume [2].

3. DESIGN SCHEME

As an underground public building, considering the four aspects of low thermal load of exterior

structures, high thermal load of human beings and equipment, large ventilation quantity, high standard fire control requirement, low electromagnetic interference to electronic audio and video equipments, through investigation , research and comparison, it is decided to use the DVM (Digital Variable Multi-link) central air conditioning system, also form a complete set to meet the need of fresh air, exhaust smoke and secondary air.

This air conditioning system is one kind of VRV air conditioning system, is suitable to moderate and small buildings with simple system structure, concentrate equipments, which is convenient to concentrate control, wire control, wireless control, energy conservation. This system made every architecture room be independent in air conditioning and made the indoor air fresh with below in and out system.

The air conditioning system adopted DVM. It used multi on line machine to burden the whole heating and cooling load (including the load of fresh air).To save energy, indoor air and fresh air exchange energy concentrate by the large scale air renewal machine located on the ground outside. Fresh air is sent to rooms by supply duct; meanwhile, part of indoor air is exhausted.

3.1 The Composition and Characteristic of DVM System

The system is made up of outdoor machine, indoor machine, refrigerant lines (conduit, branch matching parts, and so on), auto-control device, and system. One outdoor machine can transfer refrigerating medium to several indoor machines through refrigerant lines. It can meet the demand of the variable cooling load and heating load through controlling the refrigerant circulation entering to a compressor and the refrigerant flux entering to units indoors.

Compared with other air conditioning systems, DVM system is characteristic by little equipment, simple pipes, saving construction area and occupation area, good economic returns. DVM system adopted ventilated system, which sent the refrigerant media indoors without chilled water system. Outdoor machines are located outdoors or on the roof, and it is no need to build refrigerating engine house and air conditioning machine house for saving construction area and reducing comprehensive investment.

The system is arranged flexible, controlled easy, good energy saving. Designers can choose indoor machines according to architecture purpose, different energy load and decoration style. The system with new digital eddy compressor can reduce energy cost and running cost efficiently by PWM, for PWM can adjust thermal capacity output by energy load. Meanwhile outdoor machines and indoor machines match well. Even operating in low energy load (30% of the rated load), the coefficient of unit performance can reach 3.4. Indoor machines can be controlled individually, so users can turn off the indoor machines when it is unnecessary to turn on, which is better to saving energy than the concentrated control system. Although the investment of DVM system is more than 30% of the ordinary central air conditioning system, its running cost is low, especially to places where stream of people and energy load changed irregularly. The ratio of annual running cost between DVM system and water chilling unit is 69.7: 100, so 30% of the running cost can be saved. The cost of DVM system during life span is 86% of the water chilling unit. Therefore the system yield good economic performance.

This unit can operate conveniently, maintenance and repair easily, be little electromagnetic interference. Because of multi controlling methods of DVM system, based on the user’s need, designers can choose indoor machines of cable or wireless system, and one way remote control, tow way remote control, unit control and concentrate control, even control by computer between the system and building auto-control. The system can diagnose automatic, display type and position of faults, and repair quickly. The load and unload of digital eddy compressors is just an simple mechanical movement, results in a little bit electromagnetic interference, has no interference to precision instrument and electron device, and improve the safety and reliability. This characteristic not only made the ant-electromagnetic device unnecessary, but also made the system more

reliable and simple.

DVM systems also response to the temperature precisely and quickly, dehumidify well, is matched longer, has no necessary to other device, and so on.

3.2 Design Scheme of the Air Conditioning System

This design selected the DVM unit according to the design heating and cooling load (including the entire load), referencing the rated heat exchange volume of indoor machines, considering the air-flow organization of different rooms. There are 17 multi embedding indoor machines mainly in performance halls, 34 one way air embedding indoor machines with different types in other rooms. The hall adopted multi units, air flowing from up to down to everywhere, four direction (three direction) blowing in. Cold air blows to anywhere from the ceiling, so the refrigerant effect is quickly and uniform. Wind volume can be adjusted. It can create the same effect in different space by setting wind volume. The air conditioning machine is in good-looking shape with thin body and can be used narrow ceiling cavity. A machine body is equipped with double heat-barrier material that is help for anti-condensation and corrosion resistant.

Small rooms adopted one way unit that is also effective in cooling. This kind of air conditioning machine is beautiful and fashionable. The small machine body occupies small area of the ceiling, and is suitable for small places. The air screen can be used long without maintenance. Its panel grid can be removed, which is convenient to clean and keep the space neat and clean.

Based on the chosen indoor machines, considering the service time, the purpose of the room, the similar group of adjacent unit should be one group and serve the same outdoor machine. When matching the indoor and outdoor machines, it is better to make the rated volume outdoors to indoors be 50%-120%. But considering the energy cost and the loss of refrigerant media when all the indoor machines open together, the ratio is 100% generally in matching indoor machines for the public building. This design chose 5 different outdoor machines located on the provided place for outdoor machines. The equipments model number and quantity of air conditioning system are showed in table 2.

The matching pipe of DVM air conditioning system is two kinds of pipes, which is liquid pipe and gas pipe. The diameter of these two kinds of pipes among branch pipes is decided by the volume of connected indoor machines, and the diameter of these two kinds of pipes between branch pipes and indoor machines is decided by the volume of indoor machines connected branch pipes. The diameters of all the refrigerant media pipes are marked in the branch pipes chart [3].

3.3 The Design of Fresh Air and Smoke Exhaust System

To determine the fresh air volume, it is based on the room scale and the number of persons, the purpose, area of the place. Based on recommend data in GB50019-2003 DESIGN CODE OF HEATING, VENTILATION, AND AIR CONDITIONING, the larger one is chosen between fresh air needed per person and the number of aeration. This decides the model number.

The design's another characteristic is adopted the same system to exhaust air and smoke, which combined the smoke exhaust system with air conditioning system. It installed necessary anti-fire valve, smoke exhaust valve, and wind controlling valve which can be switched according to the condition. When the ventilation and smoke proof system is open, anti-fire valve should be closed. According to the seasons and the temperature, the direct current delivery system or heat recovery system can be used. The design can save much energy, reduce allocate power, reduce running cost and is suitable to many kinds of public buildings.

Fresh air and air change house are showed in Fig.1. The air conditioning units are showed in Fig.2. Fresh air blowing-in system is showed in Fig3. Ventilation and smoke exhaust system is showed in Fig.4 [4].

4. CONCLUSION

From the examples above, it is better to adopt to

household central air conditioning system for scattered, indeterminacy in time and load users. It can anti electromagnetic inference to choose the digital eddy units in places where wireless system is often used. To match household central air conditioning system with the fresh air, renewal system is becoming one optimization, which is an ideal air conditioning mode. The same system serves both exhaust wind and smoke. Sometime as the system developed, the system function can be perfect to meet numerous ways need.

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Tab. 1 Indoor design parameters

Room	Temperature indoor		Relative humidity		Outdoor air volume m^3/h per person	Noise db
	Summer	Winter	Summer%	Winter%		
Office	26± 2	20±2	55±10	45±10	20～25	45
KTV	26±2	20±2	55±10	45±10	25～30	50

Tab. 2 Equipment model number and quantity

Name	Type	Model number	Quality (set)
Outdoor machines of digital central air conditioning	Heating and cooling	RVAH100GAM0	1
		RVAH140GAM0	1
		RVAH160GAM0	1
		RVAH220GAM0	1
		RVAH260GAM0	1
Indoor machines of digital central air conditioning	Embedded type (muti direction air current)	AVMCH052EA0	12
		AVMCH070EA0	1
		AVMCH128EA0	6
	Embedded type (one direction air current)	AVMKH020EA0	28
		AVMKH035EA0	16
	Subtotal		63
Other equipments	Fume extractor	GYF－8I	2
	Discharge fan on roof	FDW－6.3#	2
	Interflow secondary air fan	SWF－5.5A	5
	Air renewal fan	XHB－L150	2

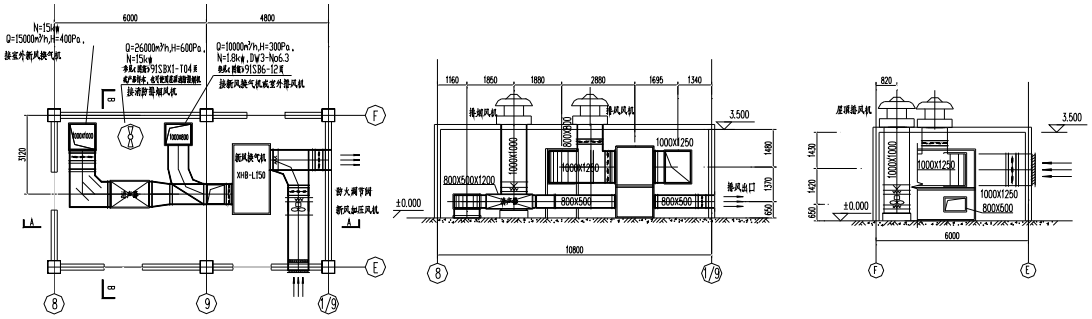

Fig.1 Plane and section plane of unit room for fresh air heat exchanger and air and smoke exhauster

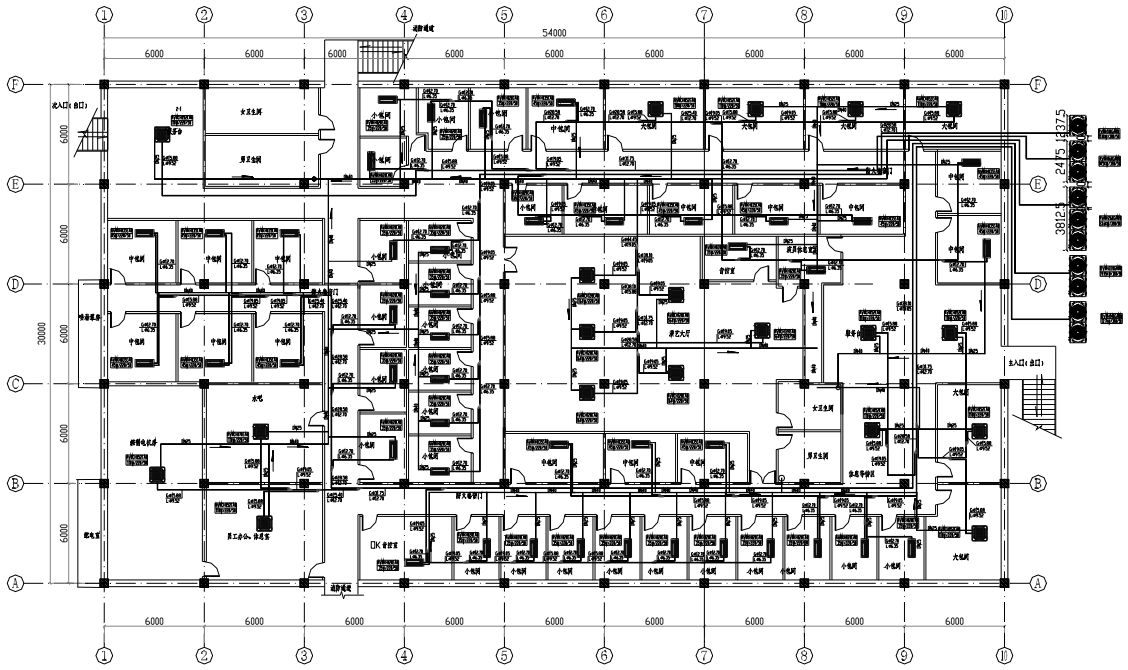

Fig.2 Plane of the lay out of outdoor and indoor units

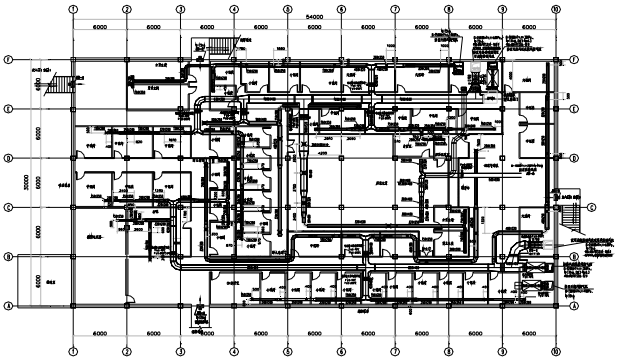

Fig.3 Plane of fresh air system

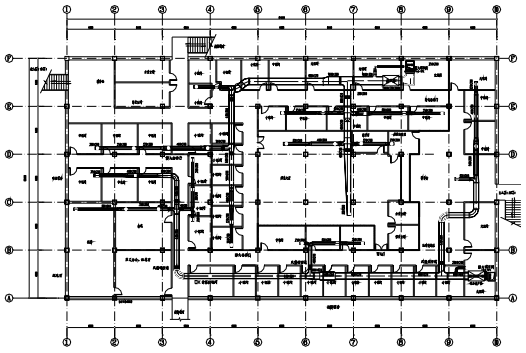

Fig.4 Plane of air and smoke exhaust system